

# OLTP and OLAP

## DATABASE DESIGN



**Lis Sulmont**  
Curriculum Manager

Our motivating question:

## How should we organize and manage data?

- **Schemas:** *How should my data be logically organized?*
- **Normalization:** *Should my data have minimal dependency and redundancy?*
- **Views:** *What joins will be done most often?*
- **Access control:** *Should all users of the data have the same level of access*
- **DBMS:** *How do I pick between all the SQL and noSQL options?*
- and more!

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**It depends on the intended use of the data.**

# Approaches to processing data

## OLTP

Online Transaction Processing



## OLAP

Online Analytical Processing



# Some concrete examples

## OLTP tasks

- Find the price of a book
- Update latest customer transaction
- Keep track of employee hours

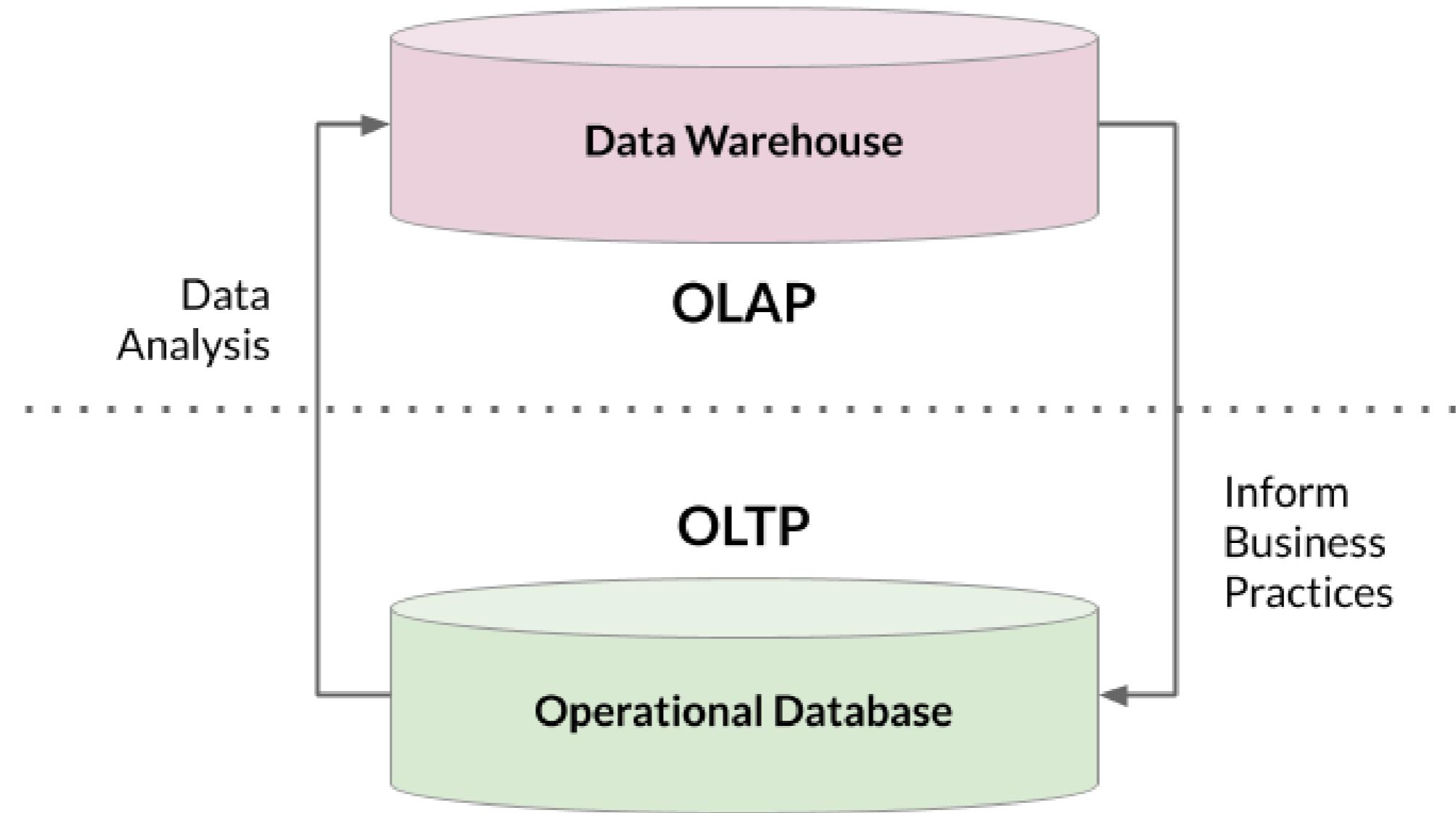
## OLAP tasks

- Calculate books with best profit margin
- Find most loyal customers
- Decide employee of the month

# OLAP vs. OLTP

	OLTP	OLAP
<i>Purpose</i>	support daily transactions	report and analyze data
<i>Design</i>	application-oriented	subject-oriented
<i>Data</i>	up-to-date, operational	consolidated, historical
<i>Size</i>	snapshot, gigabytes	archive, terabytes
<i>Queries</i>	simple transactions & frequent updates	complex, aggregate queries & limited updates
<i>Users</i>	thousands	hundreds

# Working together



# Takeaways

- Step back and figure out business requirements
- Difference between OLAP and OLTP
- OLAP? OLTP? Or something else?

# **Let's practice!**

**DATABASE DESIGN**

# Storing data

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SQL

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# Structuring data

## 1. Structured data

- Follows a schema
- Defined data types & relationships

\_e.g., SQL, tables in a relational database \_

## 3. Semi-structured data

- Does not follow larger schema
- Self-describing structure

e.g., NoSQL, XML, JSON

## 2. Unstructured data

- Schemaless
- Makes up most of data in the world

e.g., *photos, chat logs, MP3*

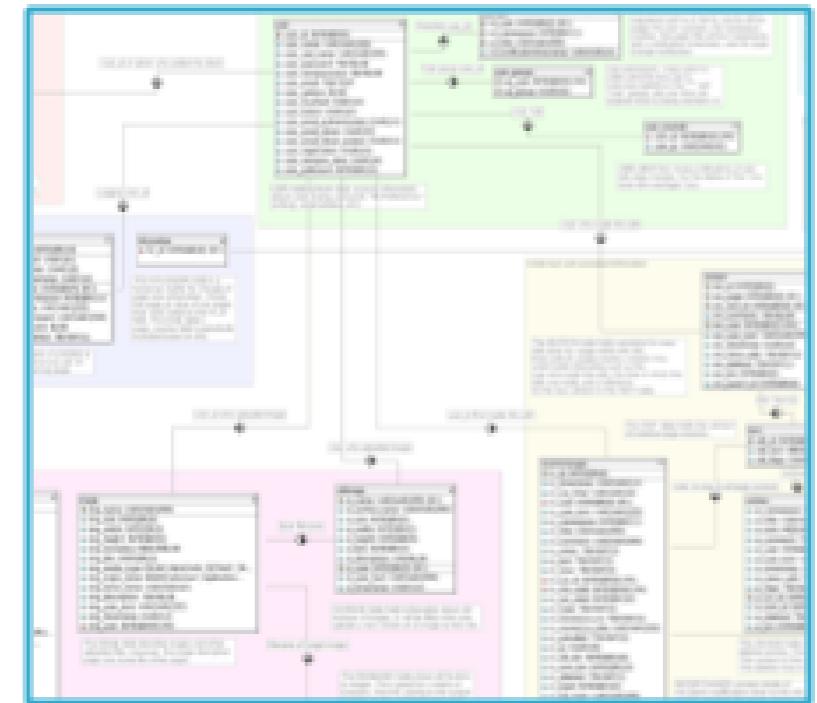
```
# Example of a JSON file
"user": {
    "profile_use_background_image": true,
    "statuses_count": 31,
    "profile_background_color": "CODEED",
    "followers_count": 3066,
    ...
}
```

# Structuring data

Easier to Analyze



```
<?xml version="1.0"
  encoding="iso-8859-1" ?>
<languages>
  <language id="fr">
    <name lang="fr">Français</name>
    <name lang="en">French</name>
    <name lang="es">Frances</name>
    <name lang="de">Französisch</name>
    <name lang="eo">Franca</name>
  </language>
```



More Flexibility and Scalability

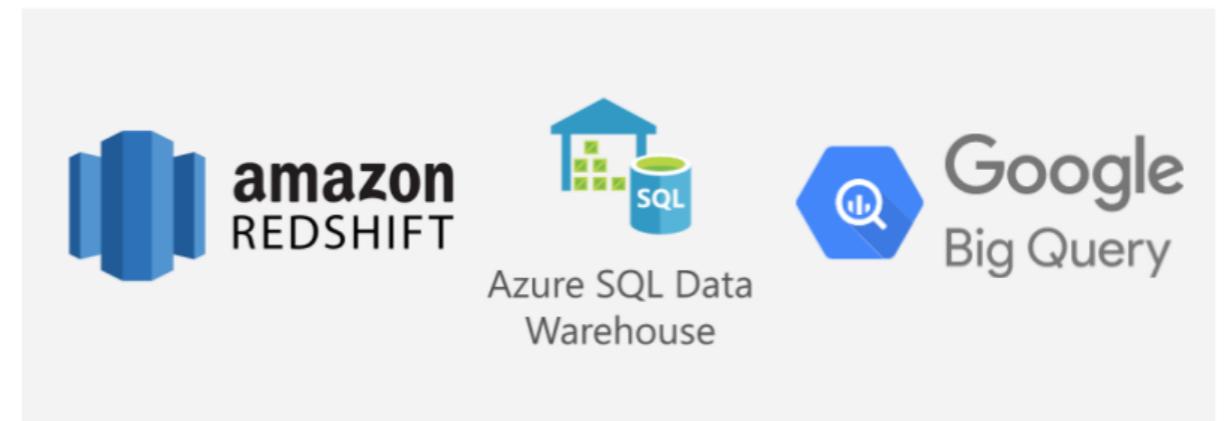
<sup>1</sup> Flower by Sam Oth and Database Diagram by Nick Jenkins via Wikimedia Commons  
[https://commons.wikimedia.org/wiki/File:Languages\\_xml.png](https://commons.wikimedia.org/wiki/File:Languages_xml.png)

# Storing data beyond traditional databases

- **Traditional databases**
  - For storing real-time relational structured data ? **OLTP**
- **Data warehouses**
  - For analyzing archived structured data ? **OLAP**
- **Data lakes**
  - For storing data of all structures = flexibility and scalability
  - For analyzing **big data**

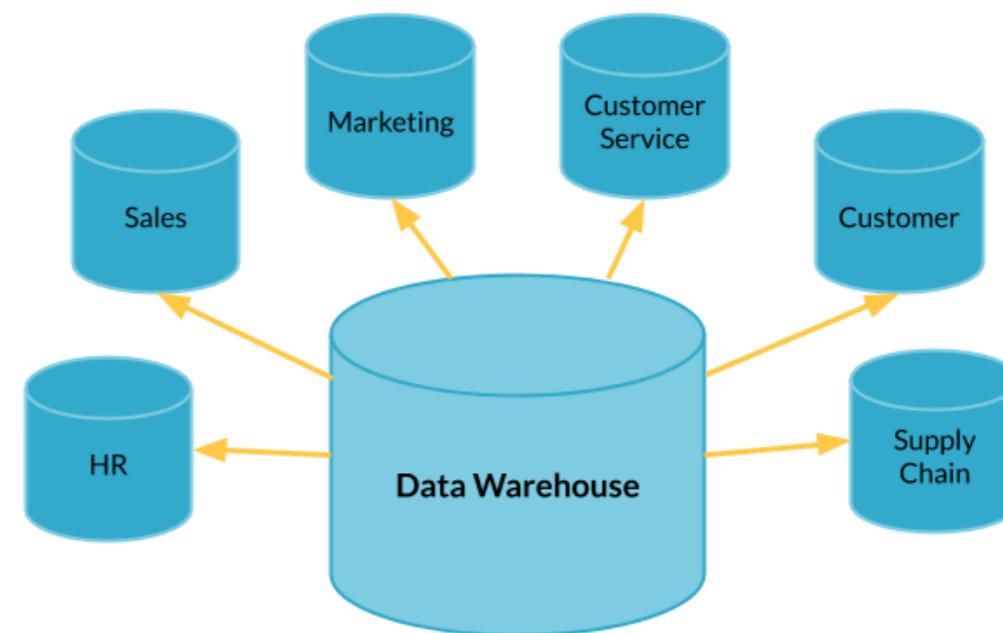
# Data warehouses

- Optimized for analytics - OLAP
  - Organized for reading/aggregating data
  - Usually read-only
- Contains data from multiple sources
- Massively Parallel Processing (MPP)
- Typically uses a denormalized schema and dimensional modeling



## Data marts

- Subset of data warehouses
- Dedicated to a specific topic

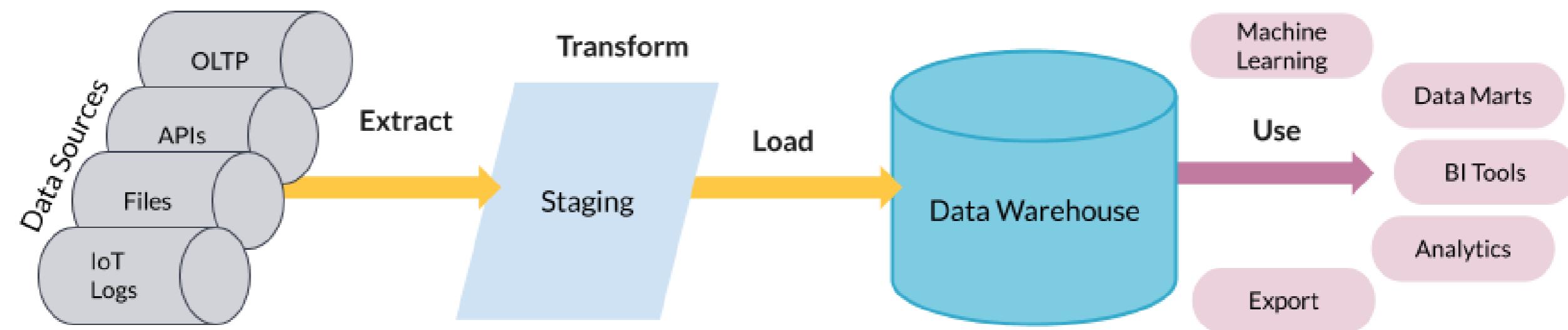


# Data lakes

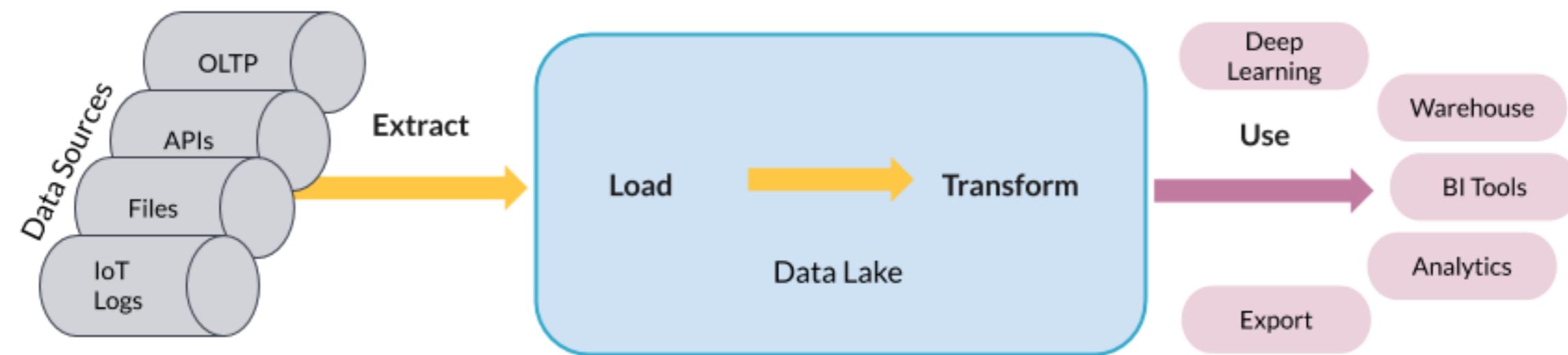
- Store ***all*** types of data at ***a lower cost***.
  - e.g., raw, operational databases, IoT device logs, real-time, relational and non-relational
- Retains all data and can take up petabytes
- Schema-on-read as opposed to schema-on-write
- Need to catalog data otherwise becomes a **data swamp**
- Run **big data analytics** using services such as **Apache Spark** and **Hadoop**
  - Useful for deep learning and data discovery because activities require so much data



# ETL



# ELT



# **Let's practice!**

## **DATABASE DESIGN**

# Database design

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SQL

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# What is database design?

- Determines how data is logically stored
  - How is data going to be read and updated?
- Uses **database models**: high-level specifications for database structure
  - Most popular: relational model
  - Some other options: NoSQL models, object-oriented model, network model
- Uses **schemas**: blueprint of the database
  - Defines tables, fields, relationships, indexes, and views
  - When inserting data in relational databases, schemas must be respected

# Data modeling

Process of creating a *data model* for the data to be stored

**1. Conceptual data model:** describes entities, relationships, and attributes

- *Tools:* data structure diagrams, e.g., entity-relational diagrams and UML diagrams

**2. Logical data model:** defines tables, columns, relationships

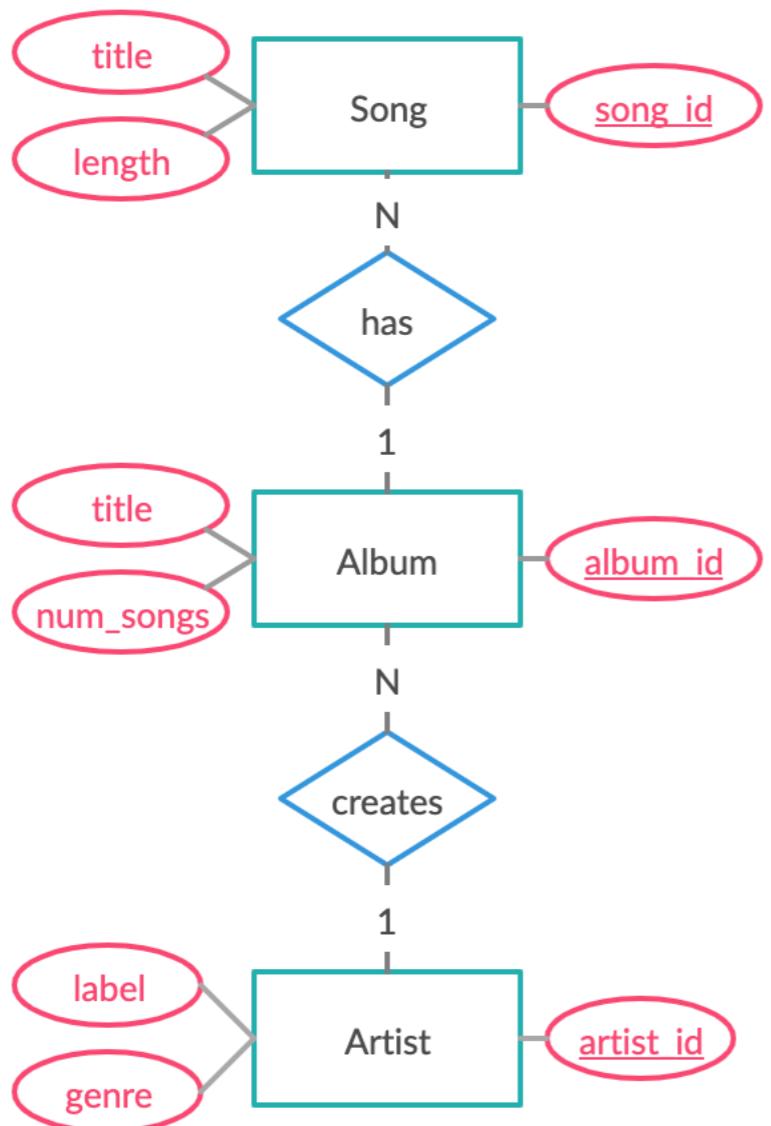
- *Tools:* database models and schemas, e.g., relational model and star schema

**3. Physical data model:** describes physical storage

- *Tools:* partitions, CPUs, indexes, backup systems and tablespaces

<sup>1</sup> [https://en.wikipedia.org/wiki/Data\\_model](https://en.wikipedia.org/wiki/Data_model)

# Conceptual - ER diagram



Entities, relationships, and attributes

# Logical - schema

Songs	
<u>song_id</u>	bigint
title	char
length	float
album_id	bigint

Albums	
<u>album_id</u>	bigint
title	char
num_songs	int
artist_id	bigint

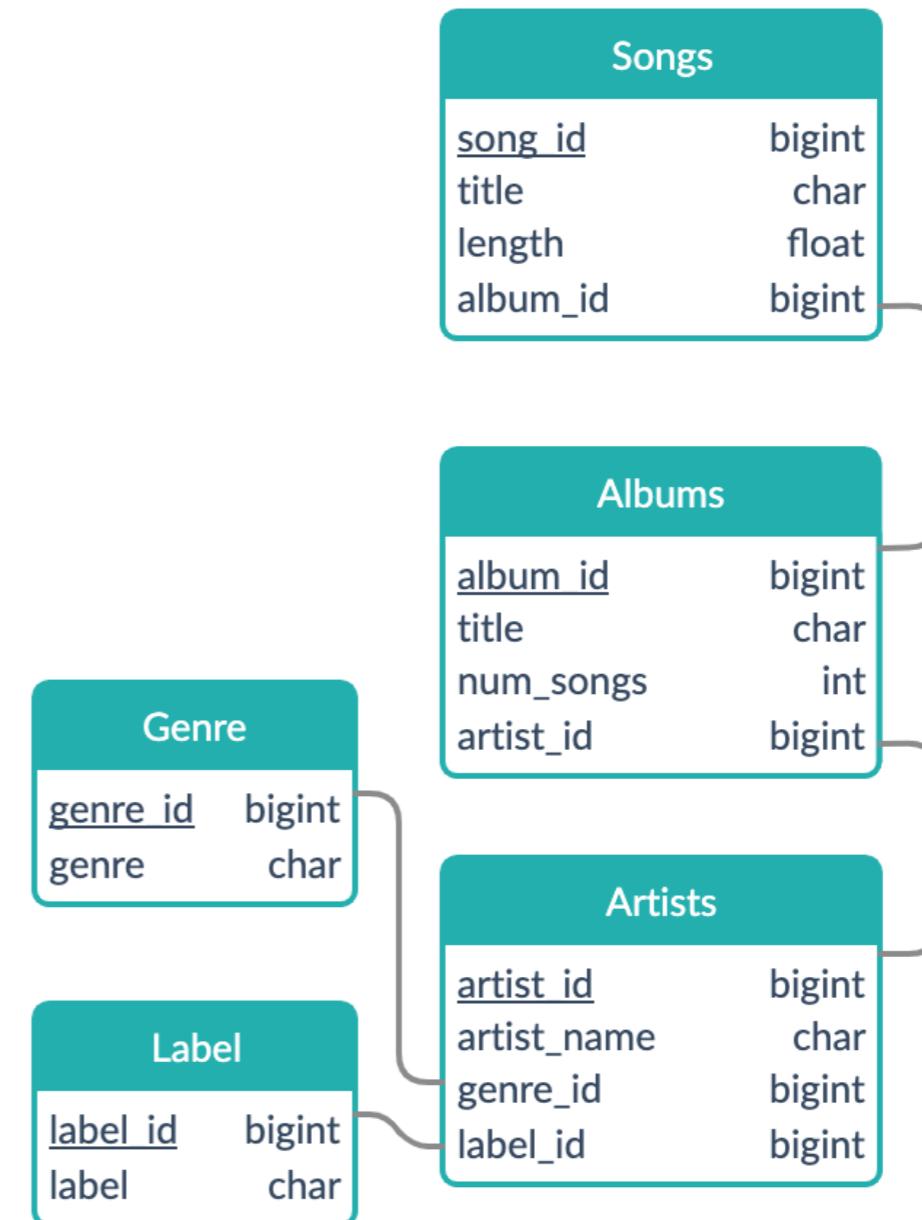
Artists	
<u>artist_id</u>	bigint
genre	char
label	char

Fastest conversion: entities become the tables

# Other database design options

Songs	
<u>song_id</u>	bigint
song_title	char
length	float
album_title	bigint
num_songs_album	int
artist_name	char
genre	char
label	char

## Determining tables



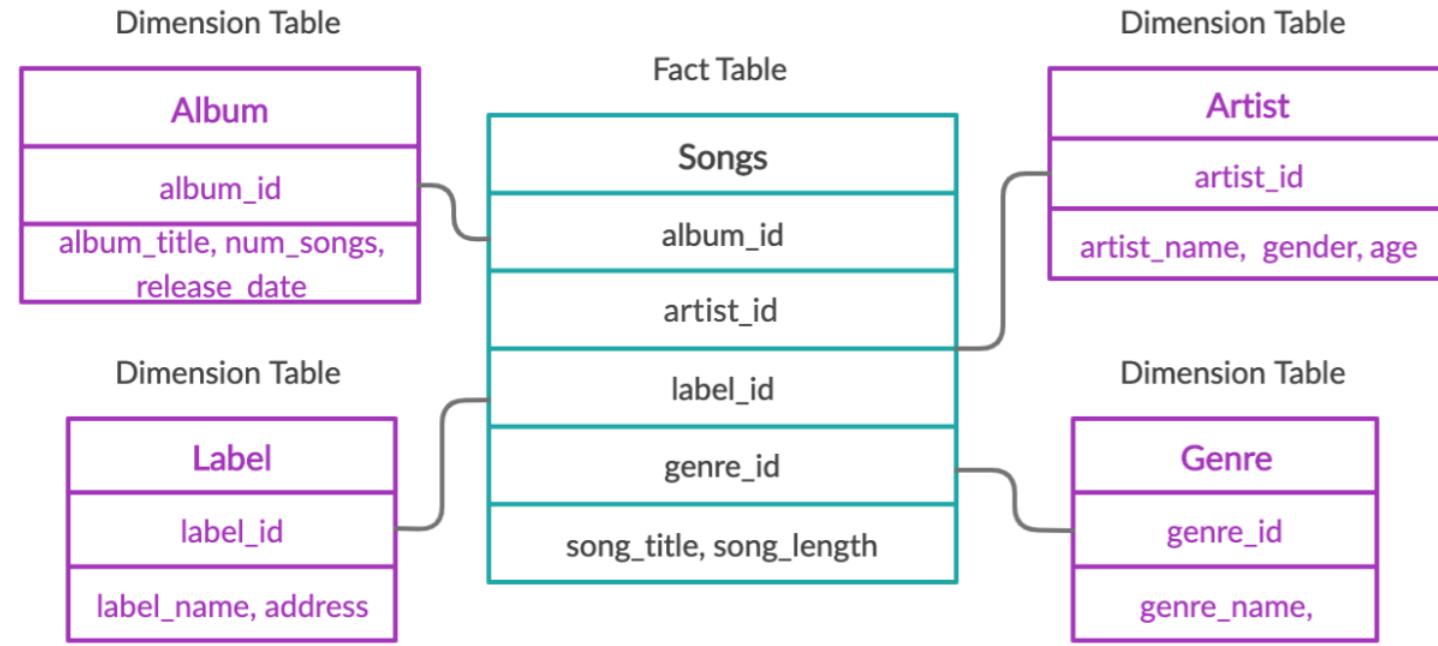
# Beyond the relational model

## Dimensional modeling

Adaptation of the relational model for data warehouse design

- Optimized for **OLAP** queries: aggregate data, not updating (OLTP)
- Built using the star schema
- Easy to interpret and extend schema

# Elements of dimensional modeling



## Organize by:

- What is being analyzed?
- How often do entities change?

## Fact tables

- Decided by business use-case
- Holds records of a metric
- Changes regularly
- Connects to dimensions via foreign keys

## Dimension tables

- Holds descriptions of attributes
- Does not change as often

# **Let's practice!**

**DATABASE DESIGN**